



**Operators Manual**

**For The**

**Model 6640T Series**

**Automatic DCC Thermometry Bridge**

[www.guildline.com](http://www.guildline.com)

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**OM6640T-10-00  
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## 1. INTRODUCTION

### 1.1. SCOPE

This document describes the operation and maintenance of the 6640T Series of Automatic DCC Resistance Bridges.

### 1.2. GENERAL DESCRIPTION

The 6640T series bridges can be controlled from the front panel or by a computer system through software. The BridgeWorks Software User's Manual describes the operation of the 6640T with the software. Once the computer system is installed and connected to the IEEE-488 Interface of the 6640T Resistance Bridge, full software control of the bridge is possible. The following models are described in this manual.

6640T-B (Base model with measurement up to 100 k $\Omega$ )

6640T-XP (eXtended Precision model with measurement up to 100 k $\Omega$ , and lower uncertainties)

## 1.3. OVERVIEW

The 6640T is a microprocessor-based, direct-current-comparator bridge designed for the automatic measurement and display of the ratio of two resistances to accuracies better than  $0.1 \mu\Omega/\Omega$ . The ratio of the two resistances is determined from a direct measurement of the voltage of the bridge imbalance while an ampere-turn balance is maintained. A microprocessor is used to control the direct-current-comparator, set the bridge measurement currents and measurement configuration, initiate the voltage measurement cycle and maintain the ampere-turn balance. This fully automated measurement process achieves optimum resistance ratio resolution and accuracy at the sub-ppm level.

The bridge is designed for flexibility and ease of use and is based on the direct-current-comparator bridge (DCC) originally developed by the National Research Council of Canada. Guildline first commercialized DCC Temperature Bridges (i.e. model 9975), and subsequently made major enhancements with the Guildline 6675(A) and 6622T automated temperature bridges.<sup>1</sup> The 6640T contains additional improvements, which are protected by two patents, and provides the best commercially available temperature bridge. Remote access to the embedded microprocessor-controller, through a simple control language command set and GPIB communication interface allows the 6640T to fully exploit the capabilities of the direct-current-comparator to suit each user requirement while still maintaining optimum resistance ratio measurement accuracy at the sub-ppm level.

The design approach taken for the 6640T results in an effective bridge measurement accuracy of 27 bits (to a maximum of 32 bits depending on configuration), allowing the resistance ratio of resistances in the range  $0.001 \Omega$  to  $100 \text{ k}\Omega$  to be automatically measured. Options are available to extend the measurement range to  $1 \text{ G}\Omega$ .

The balance of the zero ampere-turn flux condition is maintained automatically using an electronic closed loop feedback network operating on the flux detector output to drive a slave power supply for the standard resistor current. The bridge balance (null voltage condition) is maintained automatically by adjusting the number of turns in series with the unknown resistor.

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<sup>1</sup> MacMartin, M.P. and Kusters, N.L., "A direct -current-comparator for four terminal resistance measurements", IEEE Trans. Instrumentation and Measurement, vol IM-15, pp.212-220, December 1966.

## 1.4. PRINCIPLE OF OPERATION

A simplified diagram of the automatic direct-current-comparator is shown in Figure 1-1. Two sets of four terminal connections hardware are provided, one set for the standard resistor and one set for the unknown resistance. A current ( $I_x$ ), set under control of the microprocessor, is passed through the variable turns of winding ( $N_x$ ) of the comparator and through the unknown resistance ( $R_x$ ). The isolated slave current ( $I_s$ ) is generated under microprocessor control, as a linear function of the number of turns ( $N_x$ ) and is forced through the fixed slave windings ( $N_s$ ) and the reference resistor ( $R_s$ ). The currents ( $I_s$ ) and ( $I_x$ ) flowing in the windings ( $N_s$ ) and ( $N_x$ ) respectively generate a net magnetic flux imbalance in the flux detector windings ( $N_d$ ). This flux imbalance is proportional to the net ampere-turn error between the two windings [ $I_s \times N_s$ ] and [ $I_x \times N_x$ ]. By sensing this imbalance with the sensitive flux detector winding and an electronic peak detector, a voltage signal is generated proportional to the sign and magnitude of the ampere-turn error. This voltage is used in a simple closed loop control configuration to adjust the slave current ( $I_s$ ) to bring the (ampere-turn) error signal to zero. At balance, the ratio of the two currents ( $I_x$  and  $I_s$ ) flowing in the two windings is the same as the ratio of the turns set for each winding ( $N_x$  and  $N_s$ ).

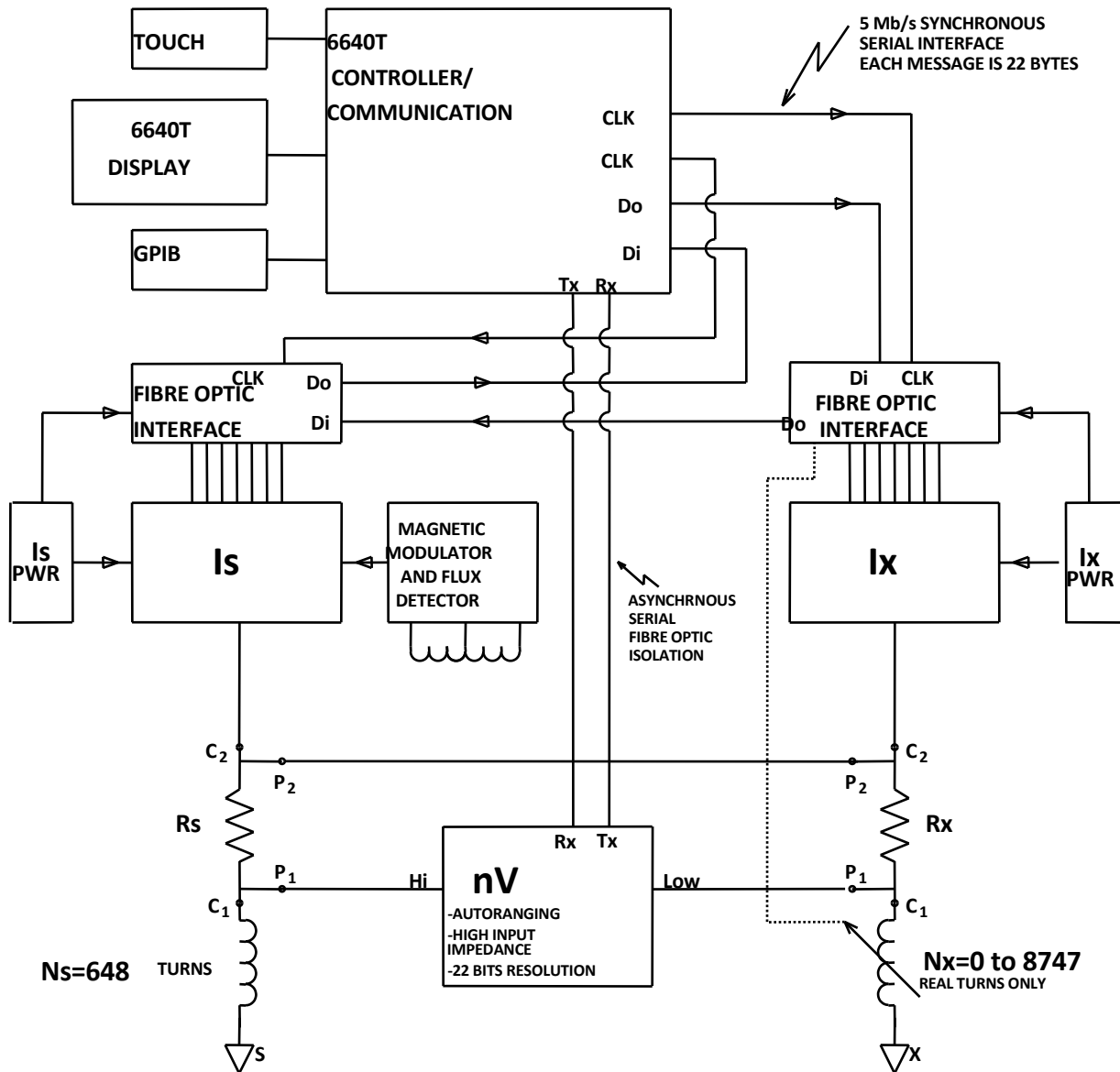
Complete electrical isolation between circuit currents is maintained throughout the 6640T by making full use of fiber optic technology. A fiber optic serial data communication link is used to transfer data between each functional component and the embedded microcontroller.

A link joining the two potential leads of the unknown resistance ( $R_x$ ) and the reference resistance ( $R_s$ ) and the nanovoltmeter detector provides the only connection between the two halves of the bridge. Power supply isolation techniques as recommended by Kibble<sup>2</sup> are used throughout to further isolate the bridge halves. The nanovolt detector is a high input impedance ( $>1 \text{ G}\Omega$ ) amplifier arrangement capable of resolving voltages at the nanovolt level with a typical linearity accuracy of 14 bits (to a maximum of 22 bits). In the automatic direct-current-comparator bridge arrangement this amplifier is used to measure the potential across the reference and unknown resistances.

Knowledge of the reference resistance value ( $R_s$ ), the effective resistance potential imbalance and confirmation that ampere-turn balance is maintained, with the turns ( $N_x$ ,  $N_s$ ) and current ( $I_x$ ,  $I_s$ ) settings, allows the unknown resistance value ( $R_x$ ) to be calculated.

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<sup>2</sup> Kibble, B.P. and Robinson, I.A., "An Isolated Mains Driven Power Supply", NPL Memorandum DES 54, September 1985.



**Figure 1-1 : Model 6640T Block Diagram**

### 1.4.1.1. Normal Ohm Measurement Mode

This mode allows a 4-terminal resistance measurement to be made from  $1 \text{ m}\Omega \leq R_x \leq 100 \text{ k}\Omega$ . No external devices (except the two resistors) are required with the 6640T to make this measurement.

## 2. PERFORMANCE SPECIFICATIONS

### 2.1. 6640T SERIES TEMPERATURE MEASUREMENT SPECIFICATION

Base Range: maximum 100 kΩ			<b>6640T-BASE</b>				
INTERCHANGE <sup>1</sup> SPECIFICATION	RESISTANCE STANDARD		3 YEAR RATIO SPECIFICATIONS <sup>2</sup>				
	◀	▶					
0.8 > Rx < 4.3	◀	ACTUAL RATIO	▶	0.08 > Rx < 0.5	0.5 > Rx < 4.3	4.3 > Rx < 13.4	13.4 > Rx < 107.5
<b>1 : 1</b>	◀	NOMINAL RATIO	▶	<b>0.1 : 1</b>	<b>1 : 1</b>	<b>10 : 1</b>	<b>100 : 1</b>
± 0.03 μΩ/Ω	◀	1 Ω	▶	± 0.2 μΩ/Ω	± 0.05 μΩ/Ω	± 0.05 μΩ/Ω	± 0.1 μΩ/Ω
± 0.03 μΩ/Ω	◀	10 Ω	▶	± 0.2 μΩ/Ω	± 0.05 μΩ/Ω	± 0.05 μΩ/Ω	± 0.1 μΩ/Ω
± 0.03 μΩ/Ω	◀	100 Ω	▶	± 0.2 μΩ/Ω	± 0.05 μΩ/Ω	± 0.05 μΩ/Ω	± 0.3 μΩ/Ω
± 0.03 μΩ/Ω	◀	1 kΩ	▶	± 0.2 μΩ/Ω	± 0.05 μΩ/Ω	± 0.1 μΩ/Ω	± 0.8 μΩ/Ω
± 0.05 μΩ/Ω	◀	10 kΩ	▶	± 0.2 μΩ/Ω	± 0.1 μΩ/Ω	± 0.2 μΩ/Ω	RESISTANCE OPTION

XP Range: maximum 100 kΩ			<b>6640T-XP</b>				
INTERCHANGE <sup>1</sup> SPECIFICATION	RESISTANCE STANDARD		3 YEAR RATIO SPECIFICATIONS <sup>2</sup>				
	◀	▶					
0.8 > Rx < 4.3	◀	ACTUAL RATIO	▶	0.08 > Rx < 0.5	0.5 > Rx < 4.3	4.3 > Rx < 13.4	13.4 > Rx < 107.5
<b>1 : 1</b>	◀	NOMINAL RATIO	▶	<b>0.1 : 1</b>	<b>1 : 1</b>	<b>10 : 1</b>	<b>100 : 1</b>
± 0.02 μΩ/Ω	◀	1 Ω	▶	± 0.1 μΩ/Ω	± 0.02 μΩ/Ω	± 0.02 μΩ/Ω	± 0.1 μΩ/Ω
± 0.02 μΩ/Ω	◀	10 Ω	▶	± 0.1 μΩ/Ω	± 0.02 μΩ/Ω	± 0.02 μΩ/Ω	± 0.1 μΩ/Ω
± 0.02 μΩ/Ω	◀	100 Ω	▶	± 0.1 μΩ/Ω	± 0.02 μΩ/Ω	± 0.02 μΩ/Ω	± 0.3 μΩ/Ω
± 0.02 μΩ/Ω	◀	1 kΩ	▶	± 0.1 μΩ/Ω	± 0.02 μΩ/Ω	± 0.05 μΩ/Ω	± 0.8 μΩ/Ω
± 0.03 μΩ/Ω	◀	10 kΩ	▶	± 0.1 μΩ/Ω	± 0.05 μΩ/Ω	± 0.1 μΩ/Ω	RESISTANCE OPTION

1 - Interchange specification (i.e. sometimes referred to as a self-calibration) with minimal filtering.

2 - 3 Year Calibration interval with annual performance verification (automated).

3 - Specifications are based on 1 mW of power and temperature of 23 °C ± 2 °C.

4 - Ranges below 1 Ohm are only available for a R<sub>s</sub> of 1 Ω.

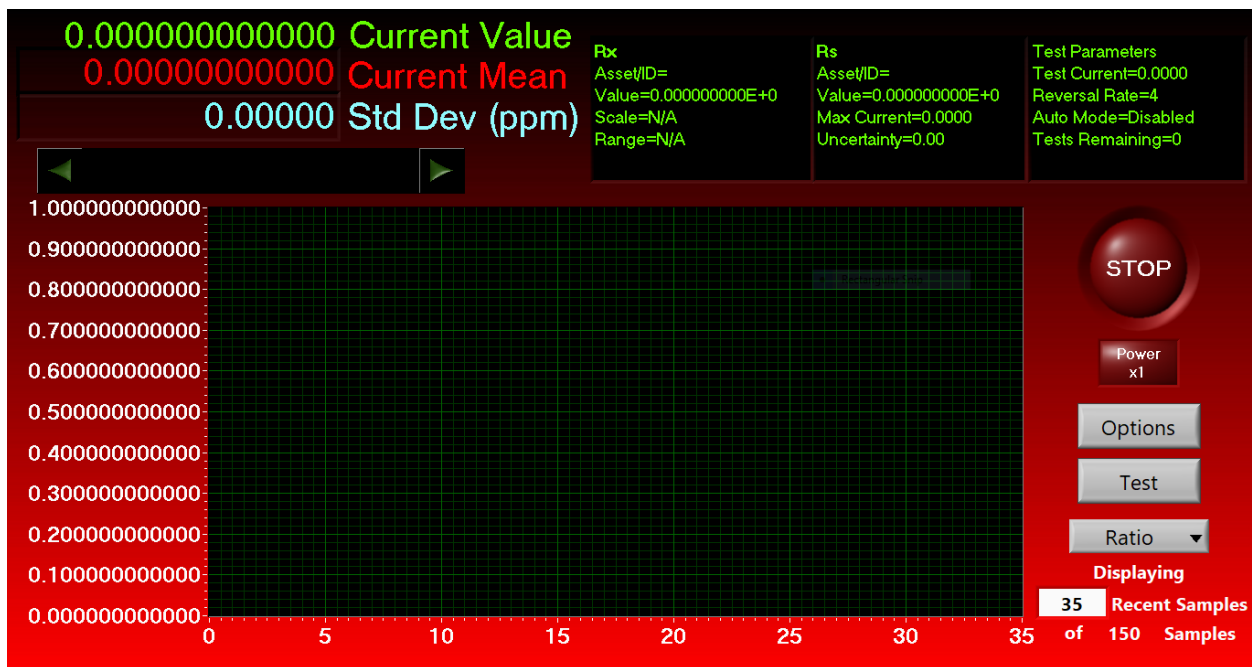
6640T Series General Specifications			
Linearity		< $\pm 0.005 \mu\Omega/\Omega$ (1:1 to 13.4:1)	
Display Resolution ( $\mu\Omega/\Omega$ )		Selectable from 0.0001 ( $\mu\Omega/\Omega$ ) to 10 ( $\mu\Omega/\Omega$ )	
Temperature Coefficient		0.01 $\mu\Omega/\Omega$ /°C of reading (Outside 23 °C $\pm$ 3 °C)	
Automatic Current Reversal Rate (in seconds)		4 to 1637 programmable, increment of 1 second	
Fastest Measurement Sample Rate		2 seconds	
Communication		USB, Network, IEEE 488.2 (Optional), SCPI Based Instructions	
Test current (for measurements to 100 k $\Omega$ )	Usable range ( $\pm$ 30 V compliance) (A)	10 $\mu$ A ~ 150 mA (extension to 10,000 A available for resistance measurements)	
	Resolution ( $\mu$ A)	1 $\mu$ A	
	Accuracy [error( $\mu$ A/A) + offset(A)]	$\pm 100 \mu$ A/A $\pm 10 \mu$ A	
Bridge Operating Temperature to Full Specifications		23 °C $\pm$ 2 °C	73 °F $\pm$ 5 °F
Bridge Maximum Operating Range (<50 % RH)		+18 °C to +28 °C	+65 °F to +82 °F
Bridge Temperature Storage Range		-20 °C to +60 °C	-4 °F to +140 °F
Power Requirements		VAC: 100 V, 120 V, 220 V and 240 V $\pm$ 10 % / 50 or 60 Hz $\pm$ 5 %, 200 VA	
Fuse Requirements (Time Delay Type)		100 V – 120 V 2.5 A (T) Guildline # 099-22501	220 V – 240 V 1.5 A (T) Guildline # 099-21501
Dimensions (Width x Height x Depth)			Weight
440 mm x 200 mm x 465 mm		17.3" x 7.8" x 18.3"	27 kg 59.5 lbs

**Note:** The 6640T-Base and 6640T-XP Models are limited to a maximum of 100 k $\Omega$  with a maximum Rs (Resistance Standard) of 10 k $\Omega$ . Because of the unique variable ratios available on all models, it is possible to measure UUT's with a variety of Rs Standards. For example, a 10 k $\Omega$  UUT could be measured with a 100  $\Omega$ , 1 k $\Omega$  and 10 k $\Omega$  Resistance Standard (Rs). To determine the measurement uncertainty due to the bridge, simply look at the Rs you are using, and then go to the appropriate UUT Sub range.

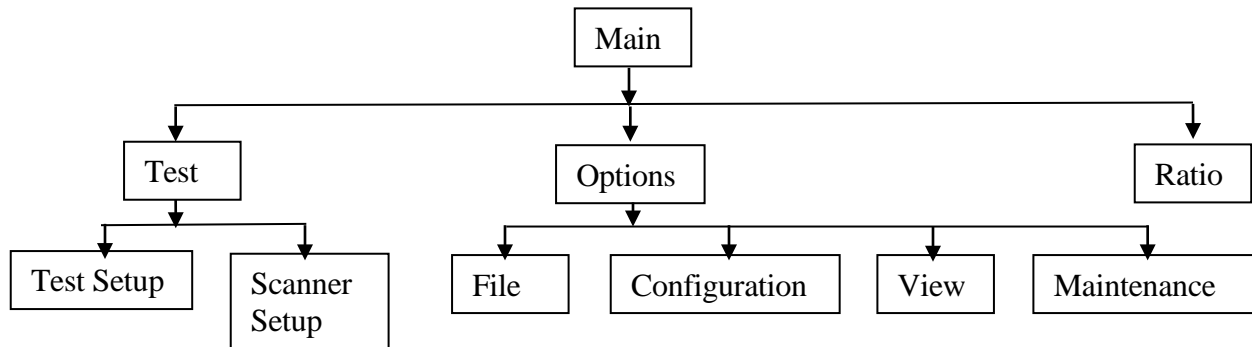
## 3. OPERATING INSTRUCTIONS

### 3.1. FRONT PANEL OPERATING PROCEDURE

The 6640 Graphical User Interface (or GUI) is provided on a Windows 10 embedded PC which is connected to the bridge hardware. The interface utilizes the touchscreen interface with on screen keyboard for user control and entry. The GUI user interface software utilizes the full screen as a “Metro” style application common to Windows 8 and newer. Note that this interface runs on Professional (x86 and x64) versions of windows and is not supported in RT versions. The 6640 GUI replaces the traditional front panel interface with an intuitive and powerful Graphical User Interface optimized for the large embedded touch screen. This interface provides manual control for individual tests.



The GUI consists of the main screen and various set up and configuration screens for controlling the bridge and displaying measurement results. In the diagram below is a high-level navigation/hierarchy map of the GUI screens.



**Figure 3-1 : User Interface Navigation Diagram**

As shown in the diagram above all screens can be easily accessed starting from the main screen of the 6640 GUI.

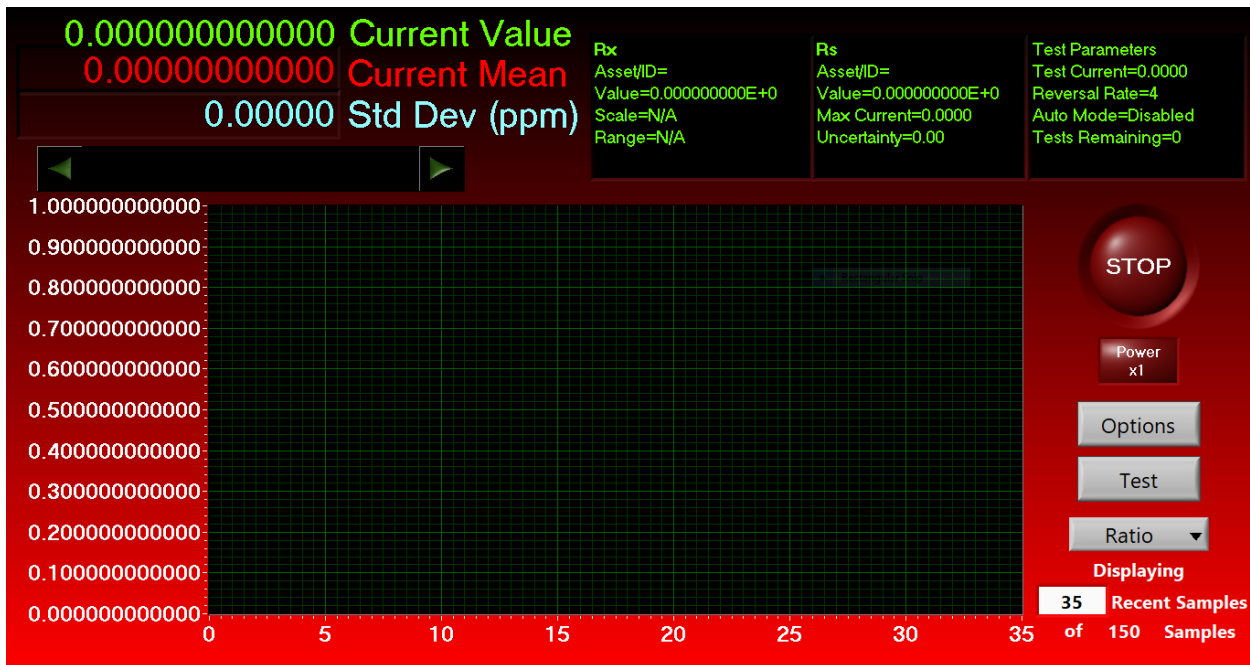
Also note that this interface can be installed and run on any computer running Windows 7 or newer and can run as a standard desktop app “Windowed”, rather than full screen “Metro” mode by changing the “TabletPC” from true to false in the “Bridge6640.ini” file.

**Note that to edit the ‘ini’ file you will need administrative privileges in Windows.**



## 3.2. MAIN SCREEN

The main screen of the user interface is where you have access to all user features of the 6640T Temperature Bridge. The screen has operator functions available mainly to the right hand side of the screen with statistics at the top of the screen and graph to the left. The graph will automatically adjust the scale such that all data will be visible up to a maximum length of hours as defined in the Setup GUI screen. If data is being logged all data is still available in the stored file.



The data on the graph can be cleared by changing the ‘Recent Samples’ count to 0, then setting it back to 35 or desired number. Note that the statistics will be cleared as well. These statistics reflect all the present data in the graph.

### 3.2.1. Stop

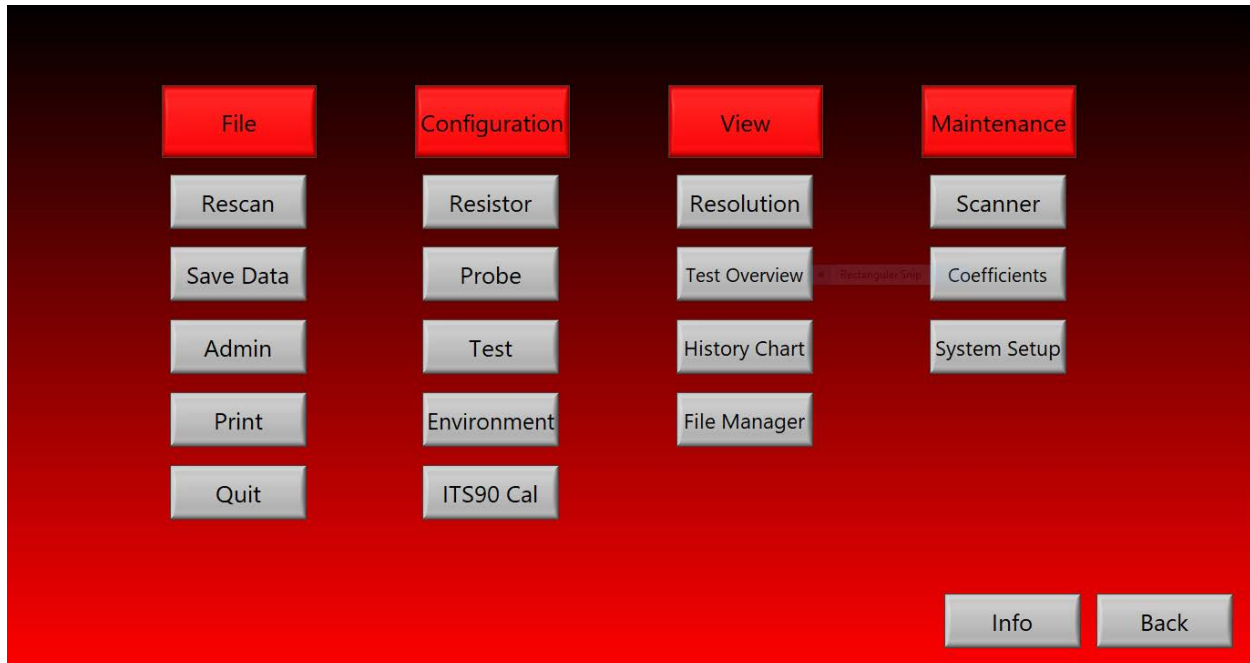
The “Stop” button stops the measurement. To exit the 6640 Graphical User Interface, Select “Quit” in the “Options” menu under the “File” drop down menu. The 6640T will retain all data if the data logging feature is turned on.

To **START** a measurement select ‘Test’, then fill in the information in ‘Test Setup’ and hit ‘Start’.

## 3.2.2. Options

The “Options” button goes to the following screen with the following options: ‘File’, ‘Configuration’, ‘View’, and ‘Maintenance’.

The “Info” selection displays Guildline contact information, and the version number of the firmware installed on the 6640T.



## Test

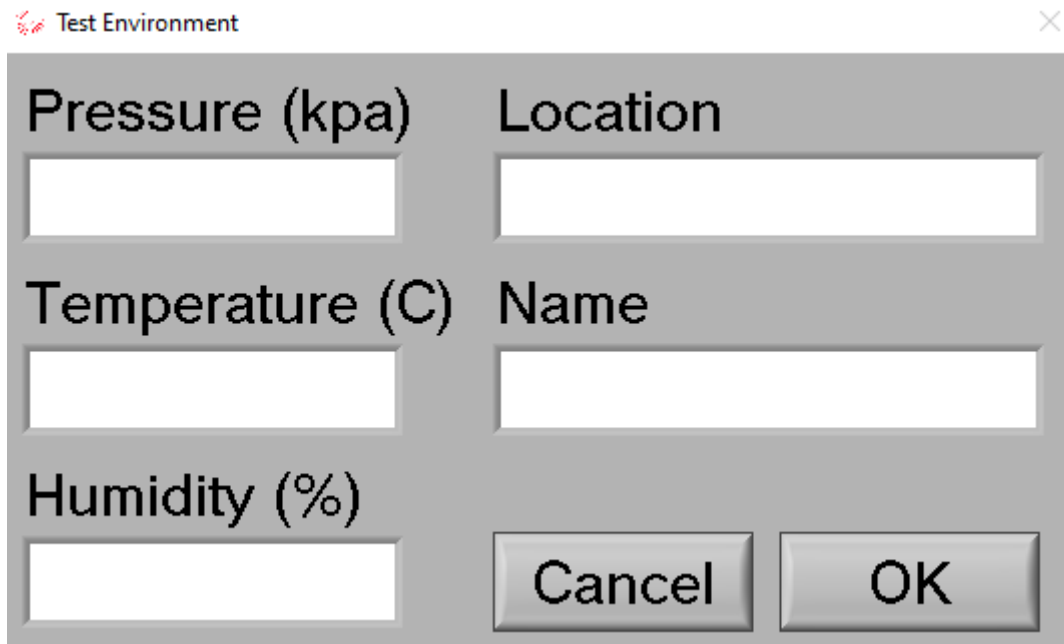
The “Test” option goes to the following screen. The ‘Scanner Setup’ portion can be ignored if a direct measurement is being made with the 6640T (i.e. no scanner is being used).

To make a **FRONT PANEL MEASUREMENT** select ‘Insert’, leave the ‘Rx Ch’, Rs Ch’ ‘mA in Normal’ and ‘Rs’ defaults as is. Select the ‘Reversal Rate’ and enter desired value. For use with a 25 Ohm SPRT it is recommended that a reversal rate of 20 seconds be used. If a power level less than 1 mW is being specified a longer reversal rate needs to be used, such as 60 seconds or even 120 seconds. Note that two measurements are made during one polarity reversal (i.e. one measurement at each polarity) so the measurement rate is ½ the reversal rate. With a reversal rate of 20 seconds a measurement will be made every 10 seconds.

To save the test parameters select ‘Save’ and a window will appear allowing you to specify the file name and directory.

To use saved test parameters select ‘Open’ and a window will appear allowing you to specify the file name and directory to use.

The ‘Environment’ selection allows you to enter a Test Name, Location, laboratory Temperature, laboratory Humidity, and laboratory Pressure; all of which will appear on the Test Report.



Test Environment

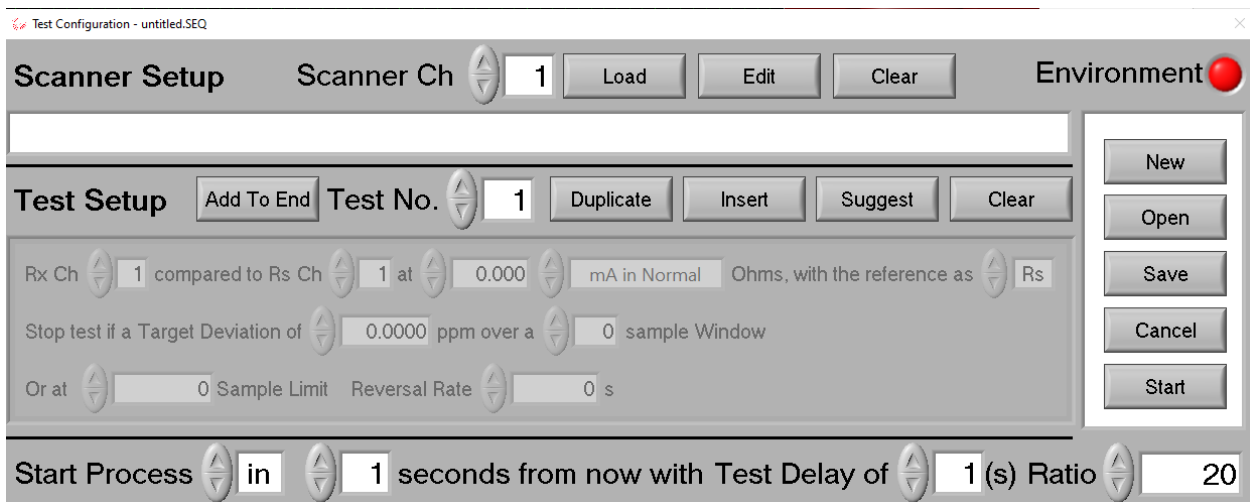
Pressure (kpa)	Location
<input type="text"/>	<input type="text"/>
Temperature (C)	Name
<input type="text"/>	<input type="text"/>
Humidity (%)	
<input type="text"/>	
<input type="button" value="Cancel"/> <input type="button" value="OK"/>	

For temperature measurements the ‘Ratio’ selection is not used.

To **START** the measurement select ‘Start’. The default is that the measurement will start in 1 second but this can be changed in the ‘Start Process’ selection.

The test will consist of the number of measurements shown in the ‘Sample Limit’, with the statistics displayed in the MAIN screen based on the last number of measurements as indicated in the ‘sample Window’. The displayed statistics will be updated after each measurement. Note that the test will automatically stop once the ‘Sample Limit’ is reached.

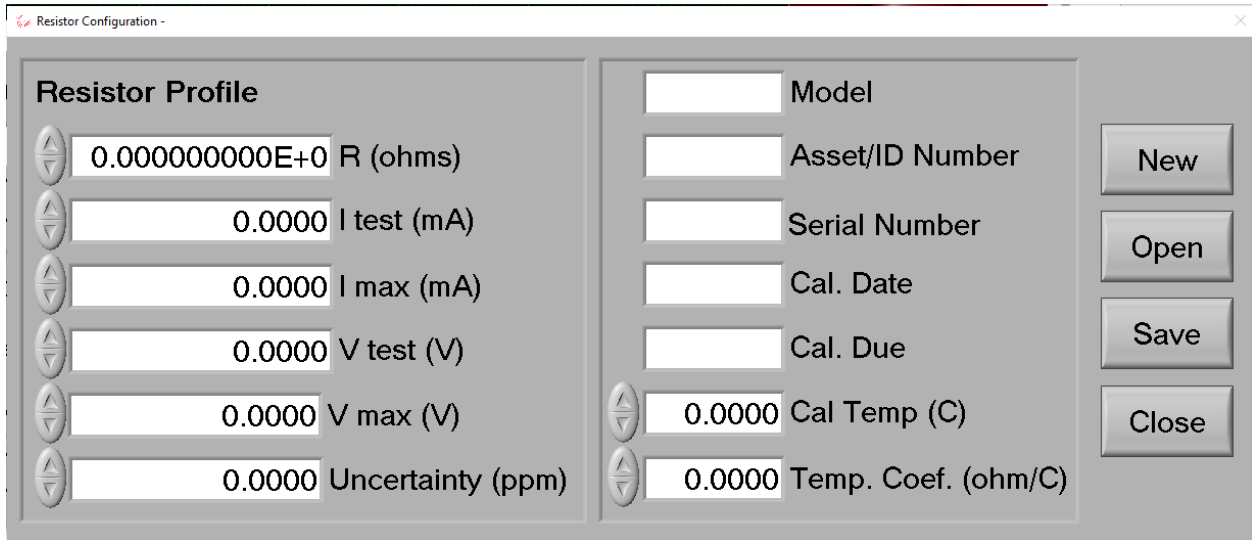
To return to the MAIN screen select ‘Cancel’



To make a **MEASUREMENT** using a scanner such as a Guildline 3210 or 6664C enter channel numbers for ‘Rx Ch’ and ‘Rs Ch’.

If a Scanner Channel setup has been previously saved it can be accessed via ‘Scanner Setup’ and selecting ‘Load’. A window will appear allowing you to specify the file name and directory.

Selecting ‘Edit’ will allow you to enter a profile for the Rs or Rx resistor as per the following screen. Typically reference resistors used for temperature measurements are used with current, not voltage.



To save the resistor profile select ‘Save’ and a window will appear allowing you to specify the file name and directory.

To select a saved resistor profile select ‘Open’ and a window will appear allowing you to specify the file name and directory.

To return to the Test Setup screen select ‘Close’

### 3.2.3. Ratio

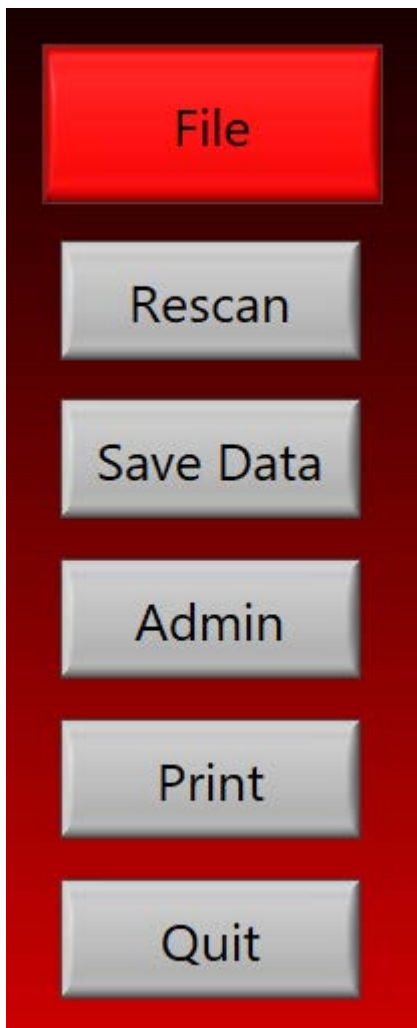
On the “Main” screen under ‘Test’ the option shows what is displayed on the graph and in the statistics (i.e. current value, current mean and standard deviation). The display options are: Ratio, Ohms, Delta PPM, Kelvin, Celsius, or Fahrenheit.

### 3.2.4. Power x1

The “Power x1” option on the main screen toggles between specified power level for Rx and the  $\sqrt{2}$  x specified power level.

### 3.3. OPTIONS FILE SCREENS

The following options are available under the “File” selection.



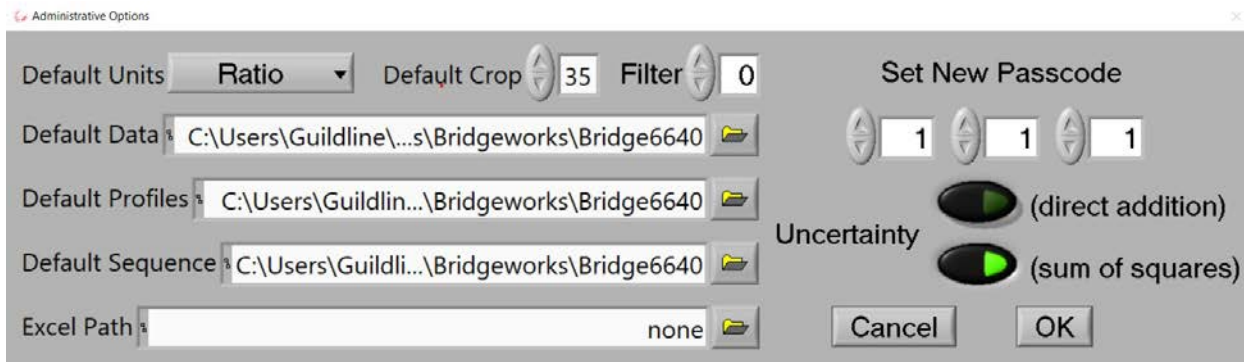
The ‘Rescan’ option uses the internal 6640T GPIB to connect the internal 6640T Windows computer running the GUI to the internal 6640T real-time computer which actually runs the bridge measurements.

Select the ‘Save Data’ option and a window will appear allowing you to specify the file name and directory where the measurement data is to be saved.

Select the 'Admin' option and the following screen appears. Making administrative changes requires a password. The default password is 111. Once the password is entered press OK.



When the correct password is entered the following 'Administration Options' screen appears. Note that the following 'Administration Options' screen is used to change the password.



The 'Default Units' option specifies what is displayed on the MAIN screen graph and on the MAIN screen statistics. The choices are Ratio, Ohms, Delta PPM, Kelvin, Celsius, or Fahrenheit. Note that the 'Units' can also be changed on the MAIN screen.

The 'Default Crop' specifies the last number of measurements to be used for the statistics that are displayed on the MAIN screen. If the 'Number of Measurements' is larger than the 'Default Crop' only the last 'Default Crop' measurements will be used for the statistics. Note that the number of measurements to be cropped can also be changed on the MAIN screen using 'Recent Samples'.

The 'Filter' selection enables a digital filter based on the last number of measurements. A simple average of the last number of measurements is reported instead of each individual measurement.

The 'Default Data', 'Default Profiles', 'Default Sequence' and 'Excel Path' are used to set the directory which will be used to store the respective information.

The 'Set New Password' option allows you to reset the Administration Password.

The 'Uncertainty' selection allows you to choose how uncertainties are combined by selecting: '(direct addition)' or '(sum of squares)'. The selection button highlighted in green shows the current setting.

The 'OK' selection button implements all changes and returns to the 'Options' screen. The 'Cancel' selection button does not make any changes and returns to the 'Options' screen.

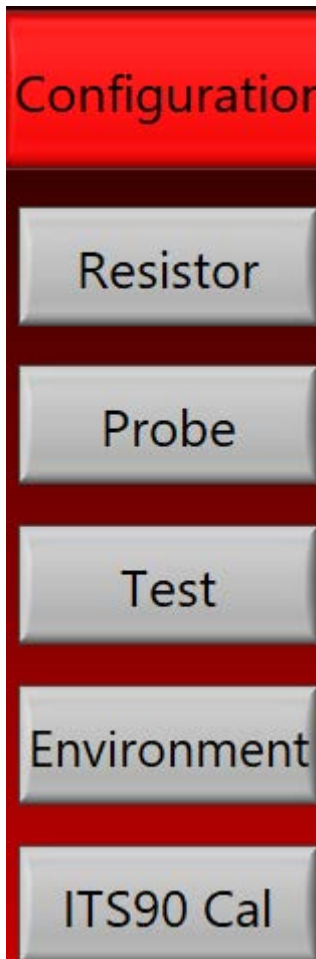
The "Print" option prints the current data file for the last measurements.

The "Quit" command exits the 6640T Main Menu and returns to Windows.



### 3.4. OPTIONS CONFIGURATION SCREENS

The following options are available under the “Configuration” selection.

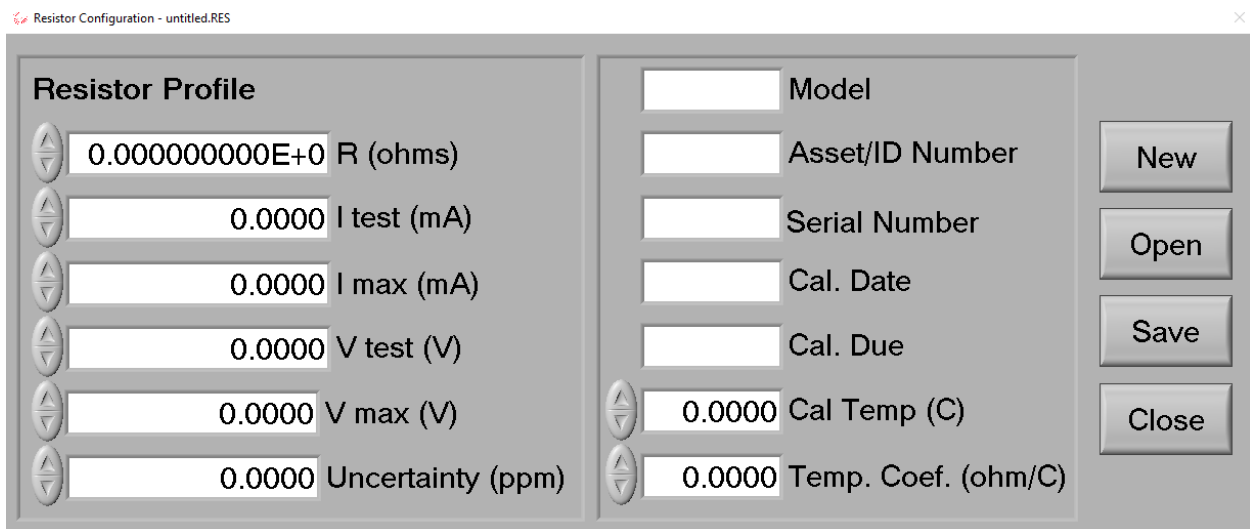


The ‘Resistor’ selection provides access to the following Resistor Profile screen. This screen allows a resistor profile to be saved and subsequently used. Note that resistance standards used for temperature measurements typically are used with current and not voltage.

The ‘New’ option allows a new resistor profile to be entered. The ‘Open’ option allows a previously stored profile to be loaded while the ‘Save’ option saves the existing resistor profile.

For both the ‘Open’ and ‘Save’ options a window will appear allowing you to specify the file name and directory where the reference resistor data is to be respectively loaded from or saved.

The ‘Close’ option returns to the “Configuration” selections.



Resistor Configuration - untitled.RES

Resistor Profile			
<input type="text" value="0.000000000E+0"/>	R (ohms)	<input type="text"/>	Model
<input type="text" value="0.0000"/>	I test (mA)	<input type="text"/>	Asset/ID Number
<input type="text" value="0.0000"/>	I max (mA)	<input type="text"/>	Serial Number
<input type="text" value="0.0000"/>	V test (V)	<input type="text"/>	Cal. Date
<input type="text" value="0.0000"/>	V max (V)	<input type="text"/>	Cal. Due
<input type="text" value="0.0000"/>	Uncertainty (ppm)	<input type="text" value="0.0000"/>	Cal Temp (C)
		<input type="text" value="0.0000"/>	Temp. Coef. (ohm/C)

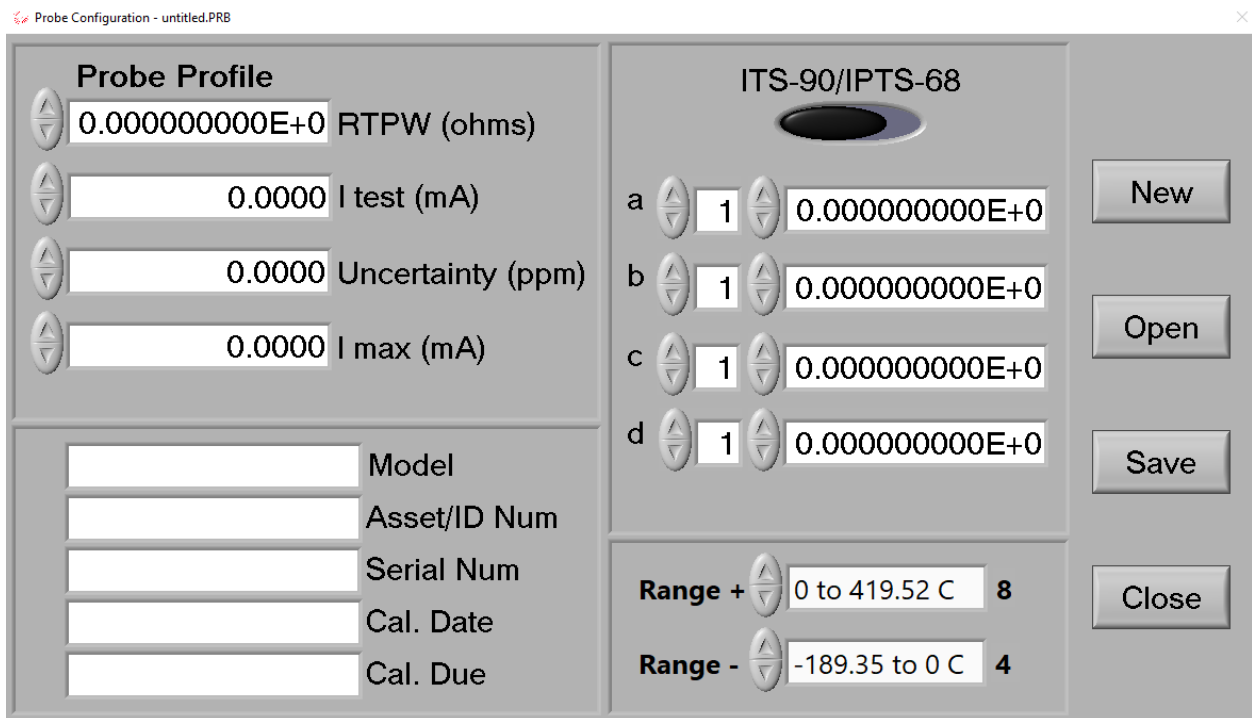
Buttons: New, Open, Save, Close

The 'Probe' selection provides access to the following Probe Configuration Screen. This screen allows a temperature probe profile, and associated ITS-90/PTS-68 coefficients, to be saved and subsequently used.

The 'New' option allows a new temperature probe profile to be entered. The 'Open' option allows a previously stored profile to be loaded while the 'Save' option saves the existing probe profile.

For both the 'Open' and 'Save' options a window will appear allowing you to specify the file name and directory where the probe data is to be respectively loaded from or saved.

The 'Close' option returns to the "Configuration" selections.

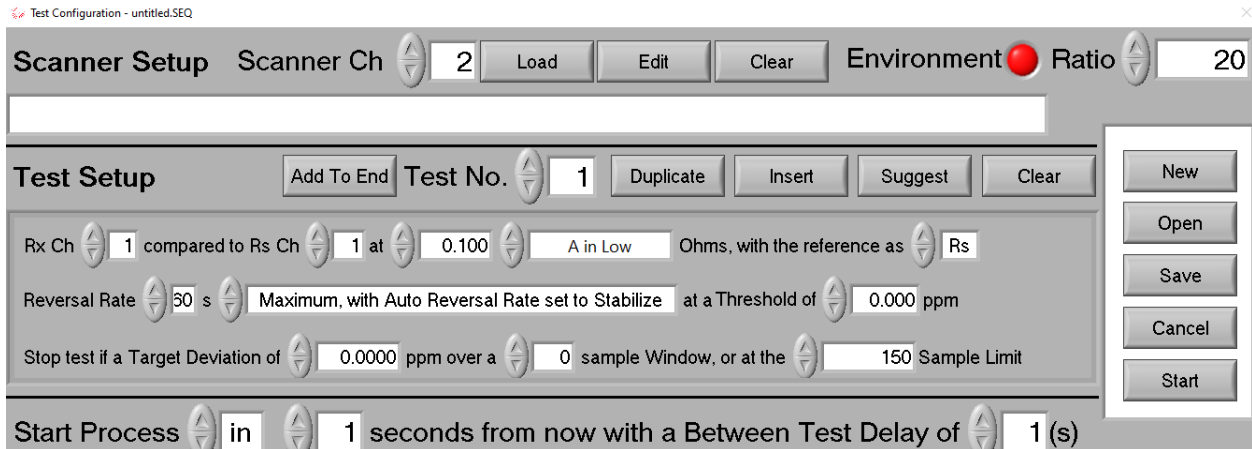


Probe Configuration - untitled.PRB

Probe Profile		ITS-90/IPTS-68			
<input type="text" value="0.000000000E+0"/>	RTPW (ohms)	a	<input type="text" value="1"/> <input type="text" value="0.000000000E+0"/>	New	
<input type="text" value="0.0000"/>	I test (mA)	b	<input type="text" value="1"/> <input type="text" value="0.000000000E+0"/>		Open
<input type="text" value="0.0000"/>	Uncertainty (ppm)	c	<input type="text" value="1"/> <input type="text" value="0.000000000E+0"/>		
<input type="text" value="0.0000"/>	I max (mA)	d	<input type="text" value="1"/> <input type="text" value="0.000000000E+0"/>		Save
<input type="text"/>	Model	Range + <input type="text" value="0 to 419.52 C"/> 8		Close	
<input type="text"/>	Asset/ID Num	Range - <input type="text" value="-189.35 to 0 C"/> 4			
<input type="text"/>	Serial Num				
<input type="text"/>	Cal. Date				
<input type="text"/>	Cal. Due				

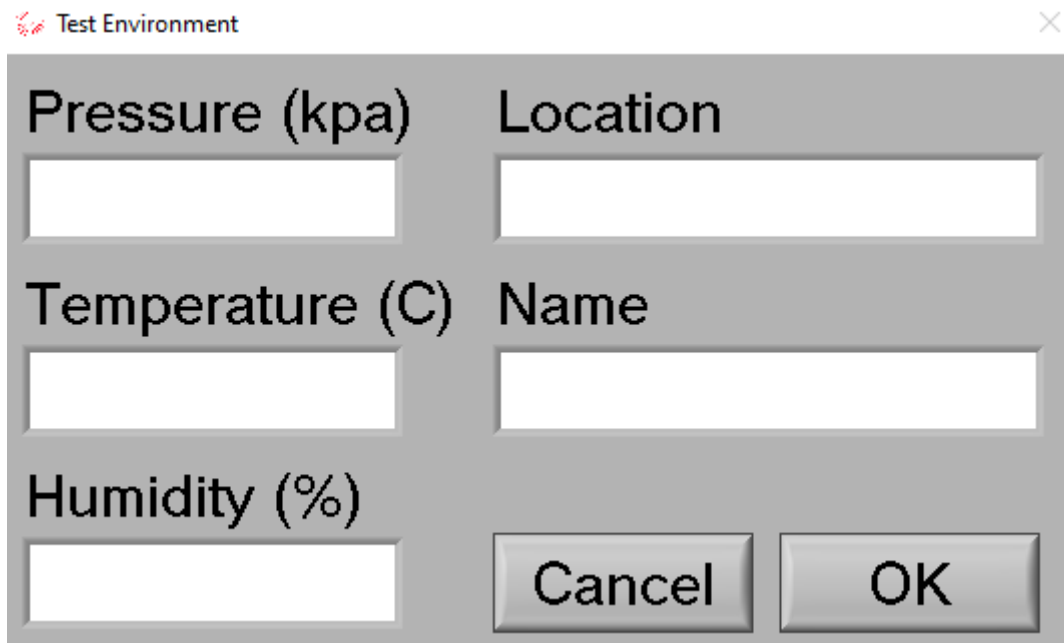
The 'Test' selection provides access to the following Test Configuration Screen.

A description of how this screen works is provided in Section 3.2.2, "Options", 'Test'.



The 'Environment' selection provides access to the following Test Environment Screen.

The 'Environment' selection allows you to enter a Test Name, Location, laboratory Temperature, laboratory Humidity, and laboratory Pressure; all of which will appear on the Test Report.



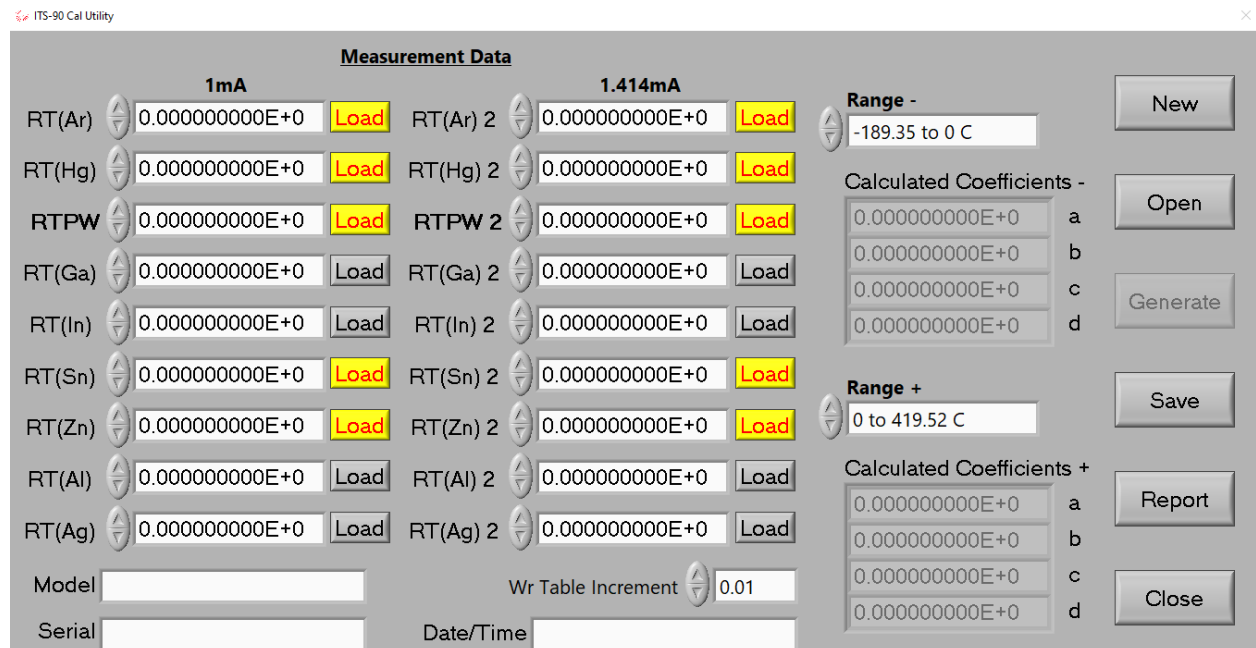
The ‘Test’ selection provides access to the following ITS-90 Calibration Utility Screen. Enter the range of temperature that a probe will be used for and the appropriate fixed points will be identified by the yellow ‘Load’. Enter the measured resistance for the probe at each respective fixed point, select ‘Generate’, and the ITS-90 coefficients will be calculated and displayed.

The ‘New’ option allows a new set of ITS-90 coefficients to be calculated.

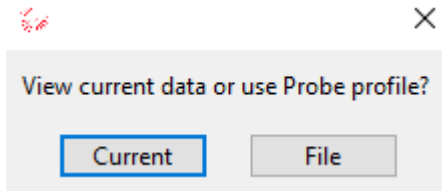
The ‘Open’ option allows a previously stored set of ITS-90 coefficients to be loaded while the ‘Save’ option saves the existing set of ITS-90 coefficients.

For both the ‘Open’ and ‘Save’ options a window will appear allowing you to specify the file name and directory where the probe data is to be respectively loaded from or saved.

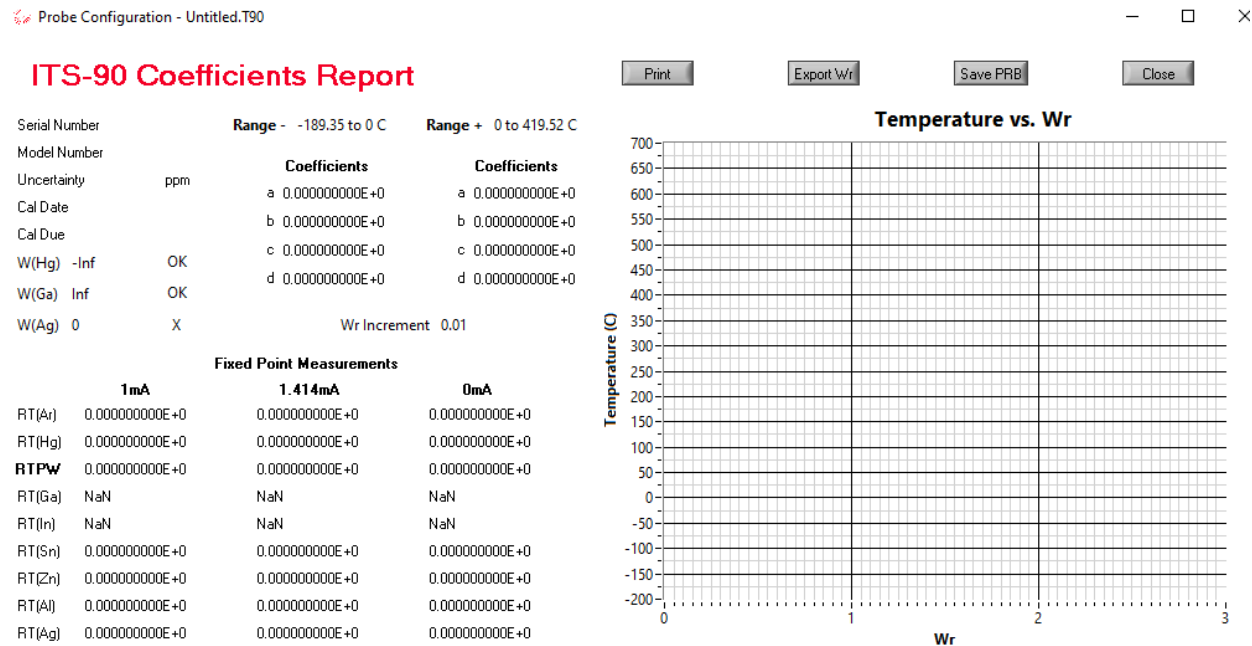
The ‘Close’ option returns to the “Configuration” selections.



The 'Report' option displays the following screen.



Selecting 'Current' displays the following report.

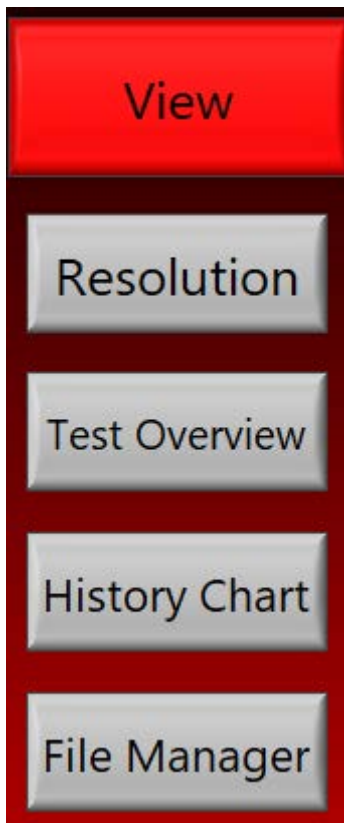


Selecting the 'File' (i.e. use Probe profile) option and a window will appear allowing you to specify the file name and directory where the probe data is to be loaded from to be used to create a ITS-90 Coefficients Report.

Hit the 'Close' button on the ITS-90 Coefficients Report to return to the 'ITS-90 Calibration Utility' Screen.

### 3.5. OPTIONS VIEW SCREENS

The following options are available under the “View” selection.



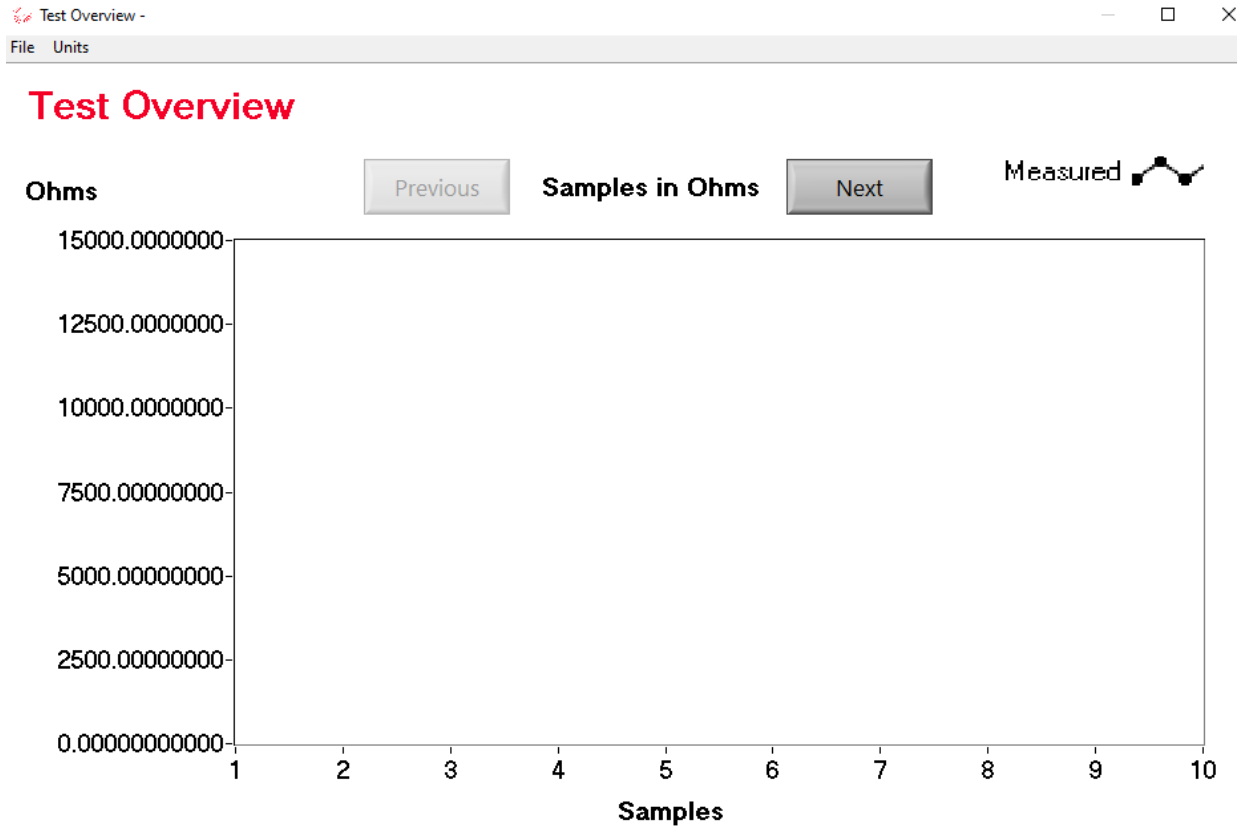
The ‘Resolution’ selection provides access to the following screen which allows you to select the resolution of the data that is displayed on the MAIN Screen.



The 'Test Overview' selection provides a graph of the current measurements as below.

Select the 'Next' option and a window will appear allowing you to specify the file name and directory with the measurement data that you want displayed.

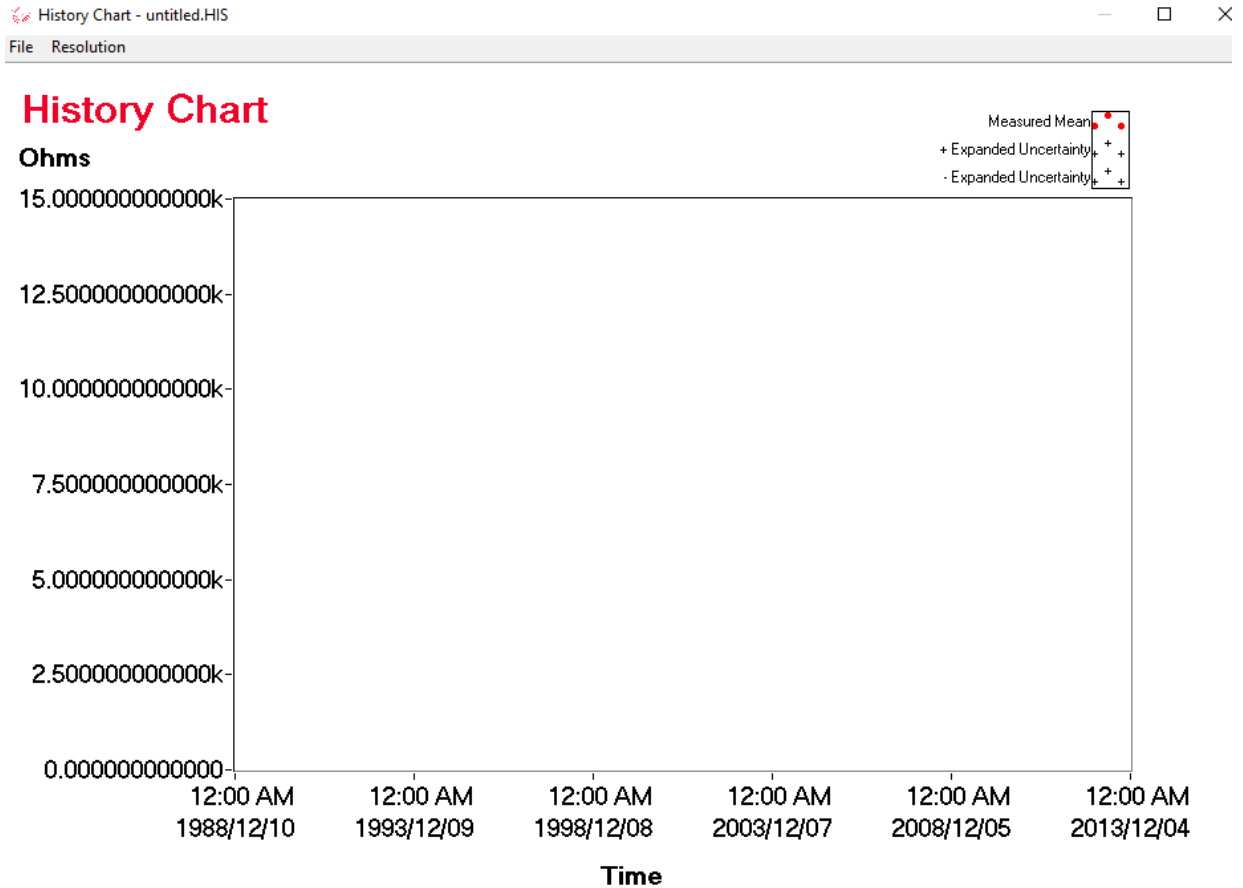
Hit the 'X' tab on the upper right of the Test Overview screen to return to the "View" menu.





The 'History Chart' selection provides a history graph of the current measurements as below.

Hit the 'X' tab on the upper right of the Test Overview screen to return to the "View" menu.



The 'File Manager' selection provides a subscreen as below.

Select the 'Directory' or 'Open' options and a window will appear allowing you to specify the file name and directory.

The 'Print' option sends the information on the File Manager screen below to a printer.

The 'Close' option returns to the Options screen.



The following options are available under the "Maintenance" selection.



The 'Scanner' option enables all specified scanner channels to be tested. Note that it is recommended that this test be run at least once a month to ensure that relays used inside a scanner do not stick (i.e. lock in open or close position).

The 'Close' selection return you to the Options screen.

Scanner Exercise Utility ×

6664A		6664A-2A	
Ch 1	<input type="radio"/> OFF/ON	Ch 17	<input type="radio"/> OFF/ON
Ch 2	<input type="radio"/> OFF/ON	Ch 18	<input type="radio"/> OFF/ON
Ch 3	<input type="radio"/> OFF/ON	Ch 19	<input type="radio"/> OFF/ON
Ch 4	<input type="radio"/> OFF/ON	Ch 20	<input type="radio"/> OFF/ON
Ch 5	<input type="radio"/> OFF/ON	Ch 21	<input type="radio"/> OFF/ON
Ch 6	<input type="radio"/> OFF/ON	Ch 22	<input type="radio"/> OFF/ON
Ch 7	<input type="radio"/> OFF/ON	Ch 23	<input type="radio"/> OFF/ON
Ch 8	<input type="radio"/> OFF/ON	Ch 24	<input type="radio"/> OFF/ON
Ch 9	<input type="radio"/> OFF/ON	Ch 25	<input type="radio"/> OFF/ON
Ch 10	<input type="radio"/> OFF/ON	Ch 26	<input type="radio"/> OFF/ON
Ch 11	<input type="radio"/> OFF/ON	Ch 27	<input type="radio"/> OFF/ON
Ch 12	<input type="radio"/> OFF/ON	Ch 28	<input type="radio"/> OFF/ON
Ch 13	<input type="radio"/> OFF/ON	Ch 29	<input type="radio"/> OFF/ON
Ch 14	<input type="radio"/> OFF/ON	Ch 30	<input type="radio"/> OFF/ON
Ch 15	<input type="radio"/> OFF/ON	Ch 31	<input type="radio"/> OFF/ON
Ch 16	<input type="radio"/> OFF/ON	Ch 32	<input type="radio"/> OFF/ON

Switch Delay
   
 (s)
   
 Iterations

The 'Coefficients' option allows you to display, print, or edit the calibration coefficients inside the 6640T Bridge.


Note that changing the calibration coefficients will affect the operation of the 6640T Bridge so a warning is displayed as below. Hit 'OK' to clear the warning message.

Select the 'Open' or 'Save' options and a window will appear allowing you to specify the file name and directory respectively of the Coefficient file to use or save.

Select the 'Edit' option to change the calibration coefficients.

Note that the calibration coefficients in the 6640T Bridge are not changed until the 'Upload' selection is made.

Select 'Close' to return to the Options menu.



Display

Print

Update

Open

Save

Edit

Close

**Date** 2024/02/23

**ADC Beta** **Cal Date** 1903/12/31

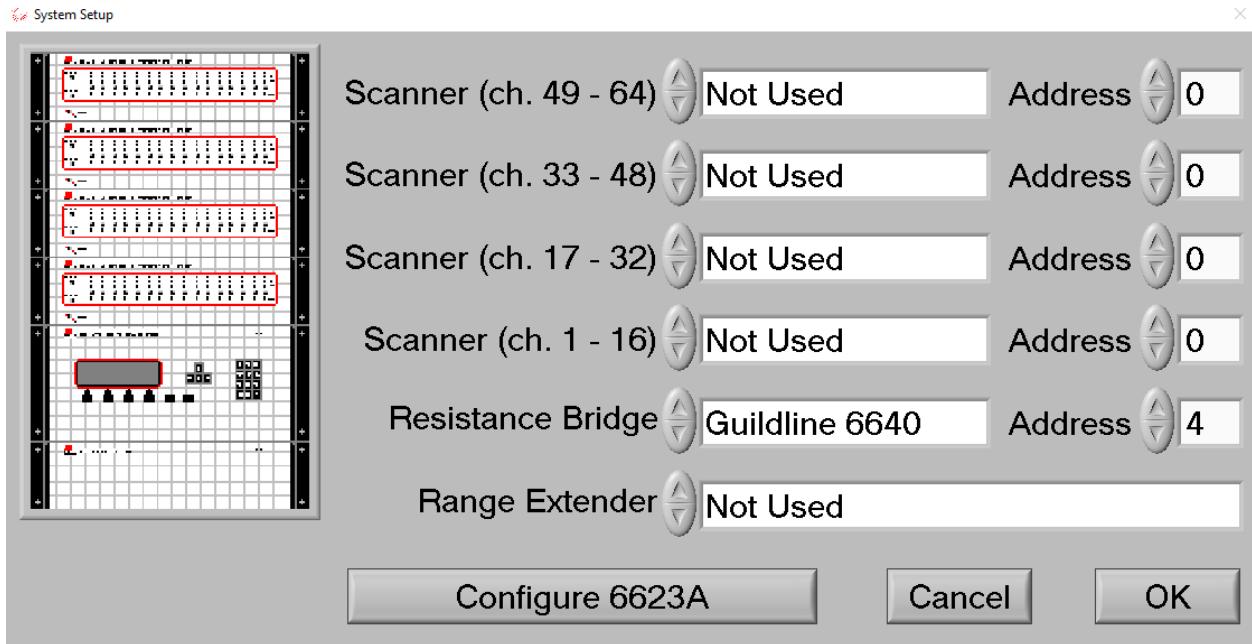
**Test Unit Model** 6640 **Date Modified** 1903/12/31

**Test Unit Serial**

Resistor (Rs)	Ratio (Rx:Rs)						
	0.1:1 (1944 turns)	1:1 (1944 turns)	10:1 (81 turns)	100:1 (81 turns)			
<b>Calculated Coefficient (ppm)</b>	0.01 Ohm	0.000E+0	0.000E+0	0.000E+0	0.000E+0	0.000E+0	0.000E+0
	0.1 Ohm	0.000E+0	0.000E+0	0.000E+0	0.000E+0	0.000E+0	0.000E+0
	1 Ohm	0.000E+0	0.000E+0	0.000E+0	0.000E+0	0.000E+0	0.000E+0
	10 Ohm	0.000E+0	0.000E+0	0.000E+0	0.000E+0	0.000E+0	0.000E+0
	100 Ohm	0.000E+0	0.000E+0	0.000E+0	0.000E+0	0.000E+0	0.000E+0
	1 kOhm	0.000E+0	0.000E+0	0.000E+0	0.000E+0	0.000E+0	0.000E+0
	10 kOhm	0.000E+0	0.000E+0	0.000E+0	0.000E+0	0.000E+0	0.000E+0
	100 kOhm	0.000E+0	0.000E+0	0.000E+0	0.000E+0	0.000E+0	0.000E+0
	1 MOhm	0.000E+0	0.000E+0	0.000E+0	0.000E+0	0.000E+0	0.000E+0
	10 MOhm	0.000E+0	0.000E+0	0.000E+0	0.000E+0	0.000E+0	0.000E+0
	100 MOhm	0.000E+0	0.000E+0	0.000E+0	0.000E+0	0.000E+0	0.000E+0
	1 GOhm	0.000E+0	0.000E+0	0.000E+0	0.000E+0	0.000E+0	0.000E+0
<b>Calculated Uncertainty (ppm)</b>	0.01 Ohm	0.000E+0	0.000E+0	0.000E+0	0.000E+0	0.000E+0	0.000E+0
	0.1 Ohm	0.000E+0	0.000E+0	0.000E+0	0.000E+0	0.000E+0	0.000E+0
	1 Ohm	0.000E+0	0.000E+0	0.000E+0	0.000E+0	0.000E+0	0.000E+0
	10 Ohm	0.000E+0	0.000E+0	0.000E+0	0.000E+0	0.000E+0	0.000E+0
	100 Ohm	0.000E+0	0.000E+0	0.000E+0	0.000E+0	0.000E+0	0.000E+0
	1 kOhm	0.000E+0	0.000E+0	0.000E+0	0.000E+0	0.000E+0	0.000E+0
	10 kOhm	0.000E+0	0.000E+0	0.000E+0	0.000E+0	0.000E+0	0.000E+0
	100 kOhm	0.000E+0	0.000E+0	0.000E+0	0.000E+0	0.000E+0	0.000E+0
	1 MOhm	0.000E+0	0.000E+0	0.000E+0	0.000E+0	0.000E+0	0.000E+0
	10 MOhm	0.000E+0	0.000E+0	0.000E+0	0.000E+0	0.000E+0	0.000E+0
	100 MOhm	0.000E+0	0.000E+0	0.000E+0	0.000E+0	0.000E+0	0.000E+0
	1 GOhm	0.000E+0	0.000E+0	0.000E+0	0.000E+0	0.000E+0	0.000E+0

The 'System Setup' allows you to enter the GPIB addresses for the 6640T Bridge and any connected scanners. The 'Configure 6623A' option is not used for temperature measurements.

The 'OK' selection returns you to the Options Menu.



## 3.6. MEASUREMENT OPERATION GUIDE

This section contains information regarding the measurement of probes in the range of 1 mΩ to 100 kΩ. This guide is provided for manual control of the model 6640T Series bridge. An operation guide for full automatic control of the model 6640T bridge, in thermometry applications, is provided in the BridgeWorks-ADV Software User’s Manual.

Ref. (Ω)	P.R.T. (Ω)	I <sub>test</sub> (mA)	I <sub>max</sub> (mA)	Reversal Rate (sec)	Comment
1	0.25	10	100	20	
1	2.5	10	100	20	
10	25	1	31.6	20	
10	100	1	31.6	20	
100	100	1	10	20	

**Table 3-1 : Recommended Temperature Measurement Test Setup**

**NOTE: I<sub>test</sub> is based on a 1 mW measurement (i.e. typically 1 mA or 10 mA).**

## 3.7. BRIDGEWORKS-ADV DATA ACQUISITION SOFTWARE

The BridgeWorks-ADV Data Acquisition Software is the control software for the model 6645T System that operates on an external computer. Using the 6640T with the BridgeWorks-ADV Data Acquisition Software will increase the functionality and the productivity of the bridge through a system level support for adding optional 6664C and/or 3210T Scanner(s). These, along with other devices, can be added to work along with 6640T to create a fully automated temperature measurement system all under software control. Before using the model 6640T system with the computer, ensure that the operation of the software package is well understood. The internal embedded computer can be used to run BridgeWorks-ADV or optionally an external computer can control the system through the IEEE-488 Interface (GPIB) of the model 6640T Thermometry Measurement Bridge, and optionally, the model 6664C and 3210T Scanners.

Refer to the BridgeWorks-ADV Software User’s Manual for a description of the software functions and automated operation of the system under software control.

## 4. MAINTENANCE

### 4.1. INTRODUCTION

This section covers troubleshooting, repair and alignment of the model 6640T Series Automatic DCC Resistance/Thermometry Bridge.

### 4.2. TEMPERATURE RATIO VERIFICATION

This section outlines the recommended thermometry based ratio verification requirements for the model 6640T bridge.

#### 4.2.1. PURPOSE

The purpose of the procedure in this section is to assure that the model 6640T Series Bridge functions properly and meets the manufacturer's specifications. It is recommended that these procedures be performed after any corrective maintenance activity, or if the operator perceives a problem.

It is recommended that all of these procedures be performed on an annual basis to verify performance of the model 6640T and for its recertification.

#### 4.2.2. EQUIPMENT REQUIRED

The following equipment is required for this procedure.

- 10  $\Omega$  standard resistor, stable to  $\pm 0.01 \mu\Omega/\Omega$  over a 24 hour period (x2)
- 100  $\Omega$  standard resistor, stable to  $\pm 0.01 \mu\Omega/\Omega$  over a 24 hour period (x2)
- 1 k $\Omega$  standard resistor, stable to  $\pm 0.01 \mu\Omega/\Omega$  over a 24 hour period (x2)
- 25  $\Omega$  standard resistor, stable to  $\pm 0.01 \mu\Omega/\Omega$  over a 24 hour period
- 400  $\Omega$  standard resistor, stable to  $\pm 0.2 \mu\Omega/\Omega$  over a 24 hour period
- Temperature controlled environment sufficient to maintain the reference and working standard resistors to their specified uncertainties

**Note: The eight standard resistors are available in the optional model 6634A Resistance Standard.**

### 4.3. MODEL 6640T BRIDGE VERIFICATION

The following procedure can be automated in using a test sequence BridgeWorks-ADV Data Acquisition Software if the 6640T is connected through a 6664C scanner.

#### 4.3.1. Set Up

1. Ensure that the model 6640T is switched on, as well as the optional 6664C and 6634A Resistance Standard if installed. Open the BridgeWorks Data Acquisition Software in the computer.

#### 4.3.2. Inputs-Outputs Verification

1. Have the following resistors ready for connection to the 6640T or pre-connected to scanner channel leads from the optional 6664C scanner as listed below:

Resistor

10  $\Omega$

25  $\Omega$

25  $\Omega$  (2)

100  $\Omega$

100  $\Omega$  (2)

300  $\Omega$

1 k $\Omega$

1 k $\Omega$  (2)

Set these standard resistors into the controlled temperature environment and allow time for them to stabilize. NOTE that without a tightly controlled temperature environment (e.g. 0.05 Deg C or better) most resistors will not be stable enough to perform a bridge verification.

2. Use the “Test Sequence” function of the “Configuration” menu of the BridgeWorks-ADV Data Acquisition Software to measure the resistance ratio of each resistor pair with the corresponding excitation current and reversal rate listed below. See the BridgeWorks-ADV Software User’s Manual for the particulars of running a test sequence. These measurements can also be made manually. If they are made manually, allow sufficient time for the measurement to settle and ensure that all measurements related to a given closure are within 24 hours of each other.



Meas. No.	R <sub>X</sub> Resistor	R <sub>S</sub> Resistor	Excitation Current	Reversal Rate	Meas. Mode
<i>Tests 1 – 13 for all 6640T bridges.</i>					
1	25 Ω	25 Ω	1.0 mA	20 sec	Normal
2	25 Ω	25 Ω	1.0 mA	20 sec	Normal
3	100 Ω	100 Ω	1.0 mA	20 sec	Normal
4	100 Ω	100 Ω	1.0 mA	20 sec	Normal
5	25 Ω	10 Ω	1.0 mA	20 sec	Normal
6	100 Ω	25 Ω	1.0 mA	20 sec	Normal
7	100 Ω	10 Ω	1.0 mA	20 sec	Normal
8	300 Ω	100 Ω	1.0 mA	20 sec	Normal
9	1 kΩ	300 Ω	1.0 mA	40 sec	Normal
10	1 kΩ	100 Ω	1.0 mA	40 sec	Normal

- For each resistor pair, calculate and report the interchange closure error. For example, if the R<sub>X</sub>:R<sub>S</sub> ratio of the first measurement is R<sub>a</sub> and the R<sub>X</sub>:R<sub>S</sub> ratio of the second measurement, where the two resistors are exchanged with one another, is R<sub>b</sub>; then the interchange error e<sub>i</sub> in parts to the 10<sup>6</sup> of the nominal ratio is:

$$e_i = (1/2) \times |R_a \times R_b - 1| \times 10^6$$

- The maximum allowable interchange closure errors (in parts to the 10<sup>6</sup>) for the following resistor pairs operating at 1 mW of power are:

Resistor	Resistor	Interchange Closure Error	
		-B	-XP
10 Ω	10 Ω	0.05	0.02
100 Ω	100 Ω	0.05	0.02
1 kΩ	1kΩ	0.05	0.02

5. For the first 10:1 ladder up closure error (100:10), the 10:1 ratio must agree to within the specification of the nominal ratio for either directly measuring the 10:1 ratio, or calculating the ratio from the product of the 10:2.5 ratio and the 2.5:1 ratio, as follows:

$$e_i = (1/3) \times |R_a - R_b \times R_c| / 10 \times 10^6$$

Where:

- R<sub>a</sub> is the 10:1 ratio
- R<sub>b</sub> is the 2.5:1 ratio
- R<sub>c</sub> is the 10:2.5 ratio

6. For the second 10:1 ladder up closure error (1k:100), the 10:1 ratio must agree to within the specification of the nominal ratio for either directly measuring the 10:1 ratio, or calculating the ratio from the product of the 10:4 ratio and the 4:1 ratio, as follows:

$$e_i = (1/3) \times |R_a - R_b \times R_c| / 10 \times 10^6$$

Where:

- R<sub>a</sub> is the 10:1 ratio
- R<sub>b</sub> is the 4:1 ratio
- R<sub>c</sub> is the 10:4 ratio

7. For the 100:1 ladder up closure error (1k:10), the 100:1 ratio must agree to within the specification of the nominal ratio for either directly measuring the 100:1 ratio, or calculating the ratio from the product of the 100:10 ratio and the 10:1 ratio, as follows:

$$e_i = (1/3) \times |R_a - R_b \times R_c| / 100 \times 10^6$$

Where:

- R<sub>a</sub> is the 100:1 ratio
- R<sub>b</sub> is the 100:10 ratio
- R<sub>c</sub> is the 10:1 ratio

8. The maximum allowable ladder up errors (in parts to the 10<sup>6</sup>) for the following resistor sets operating at 1 mW of power are:

Resistor	Resistor	Resistor	Ladder Closure Error	
			-B	-XP
10 Ω	25 Ω	100 Ω	0.05	0.02
100 Ω	400 Ω	1 kΩ	0.05	0.02
10 Ω	100 Ω	1 kΩ	0.05	0.02

## 5. REMOTE CONTROL

### MODEL 6640 PROGRAMMING COMMAND SUMMARY

A brief description of each of the possible remote IEEE-488 commands and their syntax in BNF (Backus Naur Form) follows:

- words inside angle brackets (ie. < and > ) are defined items
  - ::= means "is defined to be"
  - | means "or"
  - [] means optional
  - required letters are shown in upper case but may be upper or lower case.
- <digit> ::= 0|1|2|3|4|5|6|7|8|9  
 <letter> ::= A|B|C|...|Z|a|b|c|...|z  
 <string> ::= <letter> | <letter><string>  
 <boolean> ::= 0|1  
 <unsigned> ::= <digit> | <digit><unsigned>  
 <nr1> ::= [+|-]<unsigned>  
 <nr3> ::= <nr1>[.<unsigned>][E<nr1>]  
 <?> ::= <letter> | <digit>  
 <\*> ::= <?> | [<\*>] :not to be confused with \*  
 <DD> ::= <unsigned> : limited to range 1...31  
 <MM> ::= <unsigned> : limited to range 1...12  
 <YYYY> ::= <unsigned> : limited to ranges 1999 and up

The STB Bits are as follows:

- bit 7 = (unused)
- bit 6 = SRQ (service request)
  - ; set when (SRQ\_mask|GPIB\_STAT\_PORT) != 0
- bit 5 = ESB (event summary)
  - ; set when bitwise AND of ESE, register is not zero
- bit 4 = MAV (message available)
  - ; set when GPIB Tx buffer has data available
  - ; cleared when the buffer is empty
- bit 3 = IFL (input buffer full)
  - ; set when input buffer is over 80% full
  - ; cleared when input buffer drops under 20% full
- bit 2 = CHK (Checksum calculation complete)
- bit 1 = RDY (ready)
  - ; set when unit has a stable reading
  - ; cleared when unit is working
- bit 0 = OVR (over range)
  - ; set when over range detected (in ISR)
  - ; cleared when over range cleared

COMMAND	COMMENT
*CLS	clear status register
*ESR?	query, display event status register
*ESE?	query, display event status enable
*ESE <unsigned>	set event status enable
*IDN?	query, display identity of unit
*OPT?	query, display any reportable options
*OPC?	query, operation complete
*OPC	set operation complete bit in event status register
*RST	reset the instrument to a known defined state
*STB?	query, display serial poll status byte
*SRE?	query, display service request mask
*SRE <unsigned>	set the service request mask
*TST?	query, display results of self test
FETCh?	fetch the most recent data value
MEASure - set the measurement parameters	
MEASure <state>	select the measurement state <state> ::= 0 1 type <boolean> 0 ::= OFF 1 ::= ON
MEASure?	query, display the measurement state of the instrument
MEASure:UNIT <unit>	select the units of measurement and instrument operation <unit> ::= R O C F K V type <letter> R ::= Ratio O ::= Ohms C ::= Celsius F ::= Fahrenheit K ::= Kelvin V ::= Volts
MEASure:UNIT?	query, display the units of measurement

COMMAND	COMMENT
MEASure:FILTer <function>	setup the digital filter for the display data <function>::= 0 1 2 type <digit> 0 ::= Filter OFF 1 ::= Decimation 2 ::= Simple average
MEASure:FILTer?	query, display the filter setup
MEASure:UPDAte <rate>	set the number of screen updates for each measurement cycle <rate>::= 0 1 2 type <digit> 0::=1 updates/cycle 1::=2 updates/cycle 2::=4 updates/cycle
MEASure:UPDAte?	query, display the screen update rate setting
MEASure:DEVIation <diff>	select the method of reporting the difference data <diff>::=0 1 2 3 4 type <digit> 0 ::= disable/normal 1 ::= parts per million 2 ::= delta change 3 ::= ppm from datum 4 ::= delta from datum
MEASure:DEVIation?	query, display the method of reporting the difference data
MEASure:RESOLution <prec>	select the precision of reporting the data <prec>::=0 1 2 3 4 type <digit> 0 ::= 0.001 ppm 1 ::= 0.01 ppm 2 ::= 0.1 ppm 3 ::= 1.0 ppm 4 ::= 10.0 ppm
MEASure:RESOLution?	query, display the precision of reporting the data

COMMAND	COMMENT
MEASure:VOLT <state>	set the state of the nanovoltmeter to measure input voltages at the potential terminals 0:== OFF 1:== ON
MEASure:VOLT?	query nanovoltmeter status
MEASure:QUICk <state>	select the quick measurement state <state>:== 0 1 type <boolean> 0 :== OFF 1 :== ON
MEASure:QUICk?	query, display the quick measurement state of the instrument
CONFigure - configure instrument operating parameters	
CONFigure:DATUm <unit>, <value>	initialize the datum to be used as the set point in all difference calculations <unit> :== R O C F K V type <letter> R:==Ratio O:==Ohms C:==Celsius F:==Fahrenheit K:==Kelvin V:==Volts <value>:==<nr3>
CONFigure:DATUm?	query, display the datum used as the set point in all difference calculations
CONFigure:FILTer <size1>,<size2>	initialize the filter coefficients <size1> :== <nr3> decimation filter coefficient <size2> :== <unsigned> N average filter coefficient
CONFigure:FILTer?	query the filter coefficients

COMMAND	COMMENT
CONFigure:RESIstor <md>, <RS_SN>, <SN>, <RX>, <Rev_Rate>, <Tst_Val>, <Tst_Max>	set the active resistor measurement configuration <mode>::= 0 1 2  type <digit> 0::=normal mode 1::=high ohms mode 2::=low ohms mode <RS>::=<nr3> ref. resistor value <RS_SN>::=<string> ref. resistor serial # <RX>::=<nr3> approximate value Rx <Rev_rate>::=<nr3> test current reversal rate <Tst_Val>::=<nr3> test current/volts <Tst_Max>::=<nr3> max current(Is)/volts for ref resistor
CONFigure:RESIstor?	query, display active resistor configuration information
CONFigure:RESIstor:DISPlay <unit>, <rate>, <filter>, <size>, <power>	set the active display parameters for resistor measurements <unit>::= R O type <letter> R::=Ratio O::=Ohms <rate>::= 0 1 2 type <digit> 0::=1 updates/cycle 1::=2 updates/cycle 2::=4 updates/cycle <filter>::= 0 1 2 type <digit> 0 :::= none 1 :::= decimation 2 :::= simple average <size>::=<unsigned> size = % for decimation

COMMAND	COMMENT
	= sample size for simple average <power>::= 0 1 2 type <digit> 0 ::= power normal X1 1 ::= power X2
CONFigure:RESIstor:DISPlay?	query, display the active resistor display setup
CONFigure:PROBe <RS>, <RS_SN>, <R0>, <PRT_SN>, <Rev_Rate>, <Tst_Val>, <Tst_Max>	set the active probe measurement configuration <RS>::=<nr3> ref. resistor value <RS_SN>::=<string> ref. resistor serial # <R0>::=<nr3> Probe resistance at ice point (IPTS68) Or triple point of water (ITS90) <PRT_SN>::=<string> probe resistor serial # <Rev_rate>::=<nr3> test current reversal rate <Tst_Val>::=<nr3> test current/volts <Tst_Max>::=<nr3> max current(Is) for ref resistor
CONFigure:PROBe?	query, display active probe configuration Information; response includes all associated coefficients see CONF:PROB:PCOE? and CONF:PROB:NCOE?



COMMAND	COMMENT
CONFigure:PROBe:DISPlay <unit>, <rate>, <filter>, <size>, <power>	set the active display parameters for probe measurements <unit>::= R O C F K type <letter> R::=Ratio O::=Ohms C::=Celsius F::=Fahrenheit K::=Kelvin <rate>::= 0 1 2 type <digit> 0::=1 updates/cycle 1::=2 updates/cycle 2::=4 updates/cycle <filter>::= 0 1 2 type <digit> 0 :::= none 1 :::= decimation 2 :::= simple average <size>::=<unsigned> size = % for decimation = sample size for simple average <power>::= 0 1 2 type <digit> 0 :::= power normal X1 1 :::= power X2 2 :::= power X0.5
CONFigure:PROBe:DISPlay?	query, display the active probe display setup

COMMAND	COMMENT
CONFigure:PROBe:COEFficient <equation_#>, <coeff_00>, <coeff_01>, ..., <coeff_n>	set the active probe conversion coefficients measurements <equation_#>::= <unsigned>: equation_# takes on a value in the range 00 through 11 for the temperature calibration range of the probe <coeff_00>::=<nr3> <coeff_xx> are coefficients 01 through n for the probe ITS90 conversion algorithm. When <equation>::=00 the IPTS68 coefficients can be set.
CONFigure:PROBe:PositiveCOEFficient?	query, display the active probe positive temperature coefficients
CONFigure:PROBe:NegativeCOEFficient?	query, display the active probe negative temperature coefficients
CONFigure:VOLTmeter <range>, <zero>, <high>, <ref>	set the voltmeter calibration coefficients <range>::= 0 1 2 3 4 type <digit>  1::= 2V range 2::= 200 mV range 3::= 20 mV range 4::= 2 mV range <zero>::=<unsigned> <high>::=<unsigned> <ref>::=<nr1>
CONFigure:VOLTmeter? <Range>	query, display the voltmeter calibration setup <range>::= 0 1 2 3 4 type <digit> 0::= 20 V range 1::= 2 V range 2::= 200 mV range 3::= 20 mV range 4::= 2 mV range

COMMAND	COMMENT
	SYSTEM - set the unit system settings
SYSTEM:COMMunicate:GPIB <address>, <mode>	setup GPIB communications <address>::= <unsigned> <mode>::= 0 1 2 type <digit> 0 ::= disable 1 ::= talk only 2 ::= talk/listen
SYSTEM:COMMunicate:GPIB?	query, display GPIB set up
SYSTEM:TERSe	respond to commands with a minimum data Set
SYSTEM:VERBose	respond to commands with a minimum data Set
SYSTEM:VERSion?	query, display the installed software version
SYSTEM:DIAGnostic:ROMChecksum?	query, display rom checksum
SYSTEM:DIAGnostic:SERialNumber <number>	assign serial number <number>::=<unsigned> Diagnostic Command Set

## COMMAND

## COMMENT

SOFCAL - set the unit calibration details

SOFCAL:COEF <ratio>, <range>, <corr>, <uncert>

<ratio>: == 0|1|2|3|4|5

0:==0.1:1 ratio

1:==1:1 ratio

2:==1:1 ratio (648 turns)

3:==10:1 ratio (648 turns)

4:==10:1 ratio (81 turns)

5:==100:1 ratio

type<digit>

<range>: == 0|1|2|3|4|5|6|7|8

type<digit>

0:==1  $\Omega$  Rs range

1:==10  $\Omega$  Rs range

2:==100  $\Omega$  Rs range

3:==1 k $\Omega$  Rs range

4:==10 k $\Omega$  Rs range

5:==100 k $\Omega$  Rs range

6:==1 M $\Omega$  Rs range

7:==10 M $\Omega$  Rs range

8:==100 M $\Omega$  Rs range

<corr>:==<nr3>

correction coefficient (parts in  $10^6$  of ratio)

<uncert>:==<nr3>

uncertainty (parts in  $10^6$  of ratio)

COMMAND	COMMENT
SOFCAL:COEF? <ratio>, <range>	query, display ratio correction coefficient <ratio>: == 0 1 2 3 4 5 0:==0.1:1 ratio 1:==1:1 ratio 2:==1:1 ratio (648 turns) 3:==10:1 ratio (648 turns) 4:==10:1 ratio (81 turns) 5:==100:1 ratio type<digit> <range>: == 0 1 2 3 4 5 6 7 8 type<digit> 0:==1 $\Omega$ Rs range 1:==10 $\Omega$ Rs range 2:==100 $\Omega$ Rs range 3:==1 k $\Omega$ Rs range 4:==10 k $\Omega$ Rs range 5:==100 k $\Omega$ Rs range 6:==1 M $\Omega$ Rs range 7:==10 M $\Omega$ Rs range 8:==100 $\Omega$ Rs range
SOFCAL <beta>	set adc beta <beta>: == <unsigned> 200 <= beta < 300
SOFCAL?	query, display adc beta for the nanovolt detector
SOFCAL:GET	Calculate adc beta for the nanovolt detector
SOFCAL: FREQuency <Hz>	set the line frequency option <Hz>: == 0 1 type <digit> 0 : == 60 Hz 1 : == 50 Hz
SOFCAL:DATE<YYYY>,<MM>,<DD>	set the calibration date <YYYY> calibration year <MM> calibration month <DD> calibration day
SOFCAL:DATE?	query, display the calibration date

<b>COMMAND</b>	<b>COMMENT</b>
SOFCAL:PRIM<state>	set the primary turns lock <state> 0 1 2 type<boolean> 0:== unlocked 1:== locked to 81 turns 2:== locked to 648 turns
SOFCAL:PRIM?	query, display the primary turns lock
Low-Level Hardware Commands	
ADconvRead?	query, display adc reading in engineering units
ADconvB?	query, display adc in raw binary units
Filter <function>	set the nano voltmeter filter <function>:==0 1 type <boolean> 0:== OFF 1:== ON
Filter?	query, display the nano voltmeter filter setting
Highres <resolution>	set the high resolution mode <resolution>:==0 1 type <boolean> 0:== OFF 1:== ON
Highres?	query, display the high resolution mode setting
HardWareFilter <status>	set the hardware filter status <status>:==0 1 type <boolean> 0:== OFF 1:== ON
HardWareFilter?	query, display the hardware filter status

COMMAND	COMMENT
IXTurns <turns>	set relay turns <turns>::= <b>&lt;unsigned&gt;</b> 0≤turns≤8747
IXTurns?	query, display relay turns setting
ISDAC <value>	set dac setting <value>::= <b>&lt;nr1&gt;</b> value == ±5 Volts
ISMux <channel>	set the multiplexer channel <channel>::= <b>0 1 2 3 4 5 7</b> type <digit> 0::= servo 1::= speedup 2::= offset 3::= +40 V 4::= -40 V 5::= primary current 7::= calibrate
ISMux?	query, display the multiplexer channel
ISResolution <resolution>	set the resolution <resolution>::= <b>0 1 2</b> type <digit> 0 :== high 1 :== medium 2 :== low
ISResolution?	query, display the resolution setting
ISSpeed <speed>	set the speed <speed>::= <b>0 1 2 3</b> type <digit> 0 :== reset 1 :== slow 2 :== moderate 3 :== fast
ISSpeed?	query, display the speed setting

<b>COMMAND</b>	<b>COMMENT</b>
OHmode <mode>	set the ohm mode <mode>::=0 1 2 type <digit> 0 ::= normal 2 ::= low ohms
OHmode?	Query, display the ohm mode
Range <range>	set the nanovoltmeter range <range>::=<unsigned> range any one of 0.002, 0.02, 0.2, 2.0, 20.0
Range?	query, display the selected range
Voltage?	query, display the nanovoltmeter measurement
RESET	reset instrument to power on reset state